A TOOTHBRUSH WITH INDIVIDUALLY EMBEDDED BRISTLES

This is a continuation-in-part of Application Serial No. 09/461,891, filed December 15, 1999.

This invention relates to a toothbrush. The toothbrush is characterized by standing plastic bristles which are individually embedded in the head of the toothbrush at a small distance from each other. Within the head of a single toothbrush, several different bristle arrangements may exist, each with a unique oral cavity functional purpose.

Conventional toothbrushes are manufactured by attaching groups of bristles ("tufts") to the plastic head of the toothbrush. The tufts can be adhered in many ways. In one well-known method, each tuft is formed from a plurality of individual bristles folded into a U-shaped configuration. The folded tufts are then inserted into apertures, or cavities, provided in the head of the toothbrush. Each folded tuft is held in place in its respective cavity by inserting a small piece of metal (called an "anchor" or "staple") into the cavity such that the bottom portion of the U-shaped tuft is located and secured between the bottom of the cavity and the staple. That portion of each folded tuft which is secured in its respective cavity is sometimes referred to as the "bristle roots". See, e.g., U.S. 3,590,438,

the disclosure of which is hereby incorporated by reference. Each tuft is made up of anywhere from 2-60 individual bristles typically having a diameter of about 0.15 to about 0.25 mm and a length of 7 to 13 mm, depending on the manufacturer's design and toothbrush type. For example, a "soft" bristled toothbrush may have different length and diameter bristles than a "medium" bristled toothbrush will have.

In another method of manufacture, each tuft again comprises a plurality of individual bristles. A number of bristle tufts, each of the tufts comprising a plurality of individual bristles, are inserted into respective holes in a first mold member such that a length of the tuft protrudes from a side of the mold member which will subsequently form an inner surface of the mold cavity for the brush body. At least a portion of the protruding length of each tuft is then fused into a mass having a larger cross-section than that of the holes at the inner side of the first mold member. The first mold member is then mated with a second mold member to define the mold cavity for the brush body and molding material is injected into the cavity to form the final brush product. See, e.g., U.S. 4,635,313, the disclosure of which is hereby incorporated by reference.

This method allows for the creation of complex and asymmetric tuft patterns that may be denser than the standard stapled tuft.

Another method of fastening bristle tufts to a bristle carrier is disclosed in WO 93/12690, the disclosure of which is hereby incorporated by reference.

One problem associated with toothbrushes manufactured with tufted bristles is that bristles incorporated into the tuft structure are not free to bend and flex independently. Thus tufted bristles cannot clean as efficiently as bristles which are free to independently follow the irregular contours along the tooth's structure. Further, the structure of the tuft limits the freedom of motion of the individual bristles, especially over the cusps, grooves and other varied terrain of the tooth structure. In addition, the interproximal access of the bristle is limited by the bulky diameter of the densely packed bristle tufts.

Another problem associated with toothbrushes manufactured with bristles in tufts is that after being used, the toothbrushes frequently do not dry out sufficiently prior to their next use. This is because the bristles are combined into bundles, which creates narrow capillaries between the bristles. The moisture from using the toothbrush may be preserved for an

extended period of time in the narrow capillaries between the bristles. The moisture may provide conditions under which bacteria and microbes may grow. If the toothbrush is used at least twice per day, as recommended by dental professionals, the period between uses may not be long enough to allow for sufficient drying. The problem is particularly noted in the region situated near the head of the toothbrush where the bristles are attached. This effect is additionally promoted by dirt particles or residues of application media, namely toothpaste, that remain in the narrow capillaries and cannot be adequately removed. The relatively close spacing of the bristles within the root region may lead to incomplete removal of toothpaste residue when the toothbrush is rinsed after use.

Therefore, there is a need for a toothbrush which provides efficient tooth cleaning, is itself easily cleaned, and dries in a relatively short period of time.

World Patent Application No. WO 96/27308 describes an article which contains a bristle carrier as well as a bristle covering. The bristle covering contains individual plastic bristles that do not contact one another. The reference teaches that the flexural stiffness of the bristles is critical to the effectiveness of the toothbrush. The stiffness of the

entire bristle covering can be varied not only by choosing varying bristle dimensions (diameter, length) and bristle materials, but also by choosing slightly varying spacing between the bristles. The bristles may be spaced apart by about 0.5 times to 4 times, in particular 1.5 to 2 times, the bristle diameter, based on the space between the exterior adjacent surfaces of the bristles. The bristles may also have a varying stiffness, for example varying diameters and/or spacing, wherein groups of bristles have the same stiffness within a group but a different stiffness from another bristle group. The bristles may be of varying lengths from the bristle carrier to the free end of the bristle. The bristles may be structured, flocked or coated on their surfaces . Also, the free ends of the bristles may be shaped.

As used herein, the term "free end" means the end of the bristle distal to the point where the bristle is attached to the toothbrush head.

In conventional toothbrushes, stiffness is substantially determined by the length of the tufts and the bristle packing density in the tuft, as well as by the diameter of the individual bristles. This latter factor has the least impact because the bristles are mutually supportive in the tuft as a result of which the flexural stiffness of the tuft is several times greater

than that of the individual bristle. Due to the separation distance between bristles in the article taught in WO 96/27308, the bristle diameter plays a much larger role in determining stiffness than when the bristles are in tufts. WO 96/27308 does not teach appropriate bristle lengths or diameters, the two most important factors in determining the bristle stiffness.

World Patent Application No. WO 99/07252 describes a toothbrush having a plastic bristle head and standing plastic bristles which are individually embedded in the bristle head. The bristles are mutually spaced apart by a small distance. The distance is specified only in that the bristle packing density is 400 to 800 bristles per square centimeter on the brush head. The reference discloses that a bristle density of 600 bristles per square centimeter is preferred. The reference further discloses bristles between about 0.095 mm and about 0.225 mm in diameter. The reference teaches: that the shorter the free length of the bristle, the smaller the diameter selected to maintain stiffness; an overall height of the toothbrush in the region of the bristle head of between 6.5 mm and 11 mm; a thickness of the bristle head of between 1.5 mm and 3 mm; and bristles of 5 mm to 9.5 mm in free length. Since the flexural stiffness of an individual bristle is significantly less than that of a tuft comprising a plurality of bristles

of the same height and diameter, this patent application discloses the use of a shorter bristle with equivalent diameter to conventional tufted brush bristles. The toothbrush with the individual bristles further makes it possible to vary the flexural stiffness in precise graduations by altering the spacing of the bristles.

WO 99/97252 also states that the individual bristle toothbrushes provide a gap-free surface, which is desirable in terms of cleaning. This is an advantage to the individual bristle technology. Since each bristle is capable of independent movement, more of the small irregularities in the tooth structure can be cleaned at one time. The entire surface of the toothbrush bristles is used to clean more efficiently to provide a better overall clean versus conventional tufted brushes. Although the total number of bristles on the conventional toothbrush is roughly equivalent to the overall number of bristles on the new individual bristle toothbrush, the new toothbrush is perceived to have over 1000 cleaning surfaces (individual bristles) versus 40 to 50 cleaning surfaces (tufts) on the conventional toothbrush.

Typical bristles in a soft tufted toothbrush have a diameter of about 0.15 mm to about 0.25 mm and free lengths from about 8 mm to about 12 mm. The dimensions disclosed in the references above are very similar to

those used in conventional tufted brushes, but because the bristles in the references are individually embedded, the flexural stiffness is substantially less than the flexural stiffness of a conventional toothbrush whose individual bristle tufts comprise a plurality of bristles. Therefore, the toothbrush with individual bristles embedded in the head as taught in the foregoing references presents several problems for the consumer. One problem is that, although some flex is desired in the bristle to adapt to the contours of the irregular tooth structure, too much flex is not beneficial in that if the bristle is too soft, it will not be able to adequately clean the teeth. There will not be enough strength in the bristle to sweep away the plaque, food debris, etc. Although one certainly does not want to make a bristle that is so stiff that it may injure the soft or hard oral tissues, a certain amount of stiffness is nevertheless required to perform the toothbrush's cleaning function.

A second problem associated with the toothbrushes disclosed in the references above is that they are perceived by the consumer as being too soft and unable to clean as well as somewhat stiffer toothbrushes. Although it is not desirable to make a toothbrush that is so stiff that it could cause damage to the oral tissues, some minimal degree of stiffness is required to provide both actual cleaning and a perception in the

consumer's mind that cleaning is being accomplished. A consumer may believe that a toothbrush that is too soft is not capable of removing plaque, food debris, etc. from the teeth. The flexural stiffness of a single bristle used in a tufted toothbrush is too low when used individually to provide the consumer with a perception that cleaning is actually being effected.

A third problem associated with the toothbrushes disclosed in the references above is that, because the flexural stiffness of the individual bristle is much less than that of a tuft comprised of a plurality of identical bristles, and since there are no supporting bristles about the periphery to return the bristle to the upright position after deflection, the individual bristles are likely to no longer appear to be in an upright, generally perpendicular position after use. Instead, the bristles will bend in all directions from the toothbrush head ("splay") after significantly fewer uses than in a tufted toothbrush. A splayed toothbrush is seen by the consumer as worn and used. Clinical studies in the literature have also shown that these splayed toothbrushes do not clean as well as an identical toothbrush that contains new, upright bristles.

A fourth problem associated with the toothbrushes disclosed in the references above is that, upon

inspection by the consumer, it is believed that the toothbrush will not last as long as a tufted toothbrush. The toothbrush containing spaced apart, individual bristles is perceived as not having the same resiliency as a tufted toothbrush and thus will need to be replaced sooner. This is mostly due to the perception that there are no other bristles helping to maintain each bristle upright. Since the splaying effect is also the main cue to the consumer that the toothbrush needs to be replaced, the product is undesirable for purchase due to the perceived shorter product life.

Therefore, despite the disclosure of the above-mentioned references, there is a continuing need for a toothbrush which provides efficient tooth cleaning, is easily cleaned, and dries in a relatively short period of time. We have surprisingly found that toothbrushes which employ larger diameter bristles having a length similar to the length of the tufts in tufted toothbrushes will solve or greatly reduce the problems described above. A thicker bristle of similar length to that used in conventional tufted toothbrushes will not only supply more rigidity to the toothbrush, thus providing a more perceivable scrubbing feeling to the user, but will also maintain the bristle length that is required to reach the interdental and subgingival areas. The thicker bristle will inherently have more structural support to resist splaying and retain its upright shape for a

longer period of time relative to a smaller diameter, equal length bristle.

In one embodiment, the present invention provides a toothbrush having: a handle; a toothbrush head distal to the handle; and a multiplicity of first type bristles, each bristle having a diameter of from about 0.25 mm to about 0.60 mm; wherein the first type bristles are individually secured, e.g., by embedding in the toothbrush head; and the bristles are mutually spaced apart from one another by a distance from 0.5 times to 10 times the diameter of the bristles.

The toothbrush handle (1) and toothbrush head (2) may be made in one piece by injection molding. The toothbrush head (2) is distal to the toothbrush handle (1). The toothbrush handle (1) and toothbrush head (2) may be made of polymers such as, but not limited to, polyethylene, polypropylene, and polycarbonate.

The first type bristles (3) and any other bristles utilized in this invention may be made from a material selected from an elastomeric material such as, but not limited to, rubber and a polymer selected from the group consisting of nylon, polyamides, polyesters, polybutylene terephthalate, polypropylene, acetal resins, fluoropolymers, polyacrylates, and polysulfones. The first type bristles and any other bristles utilized

within this invention may be structured, flocked or coated on their surface area. The first type bristles and any other bristles utilized in this invention may contain additives such as, but not limited to abrasives and polishing agents; anti-cavity agents such as sodium fluoride; antimicrobial agents, and combinations thereof.

In the first embodiment of the invention, it is preferred that the first type bristles (3) all have the same free length. As used herein, the term "free length" means the length of the bristle from inner surface (9) of the toothbrush head to the free end of the bristle. The space between the exterior surfaces of adjacent first type bristles (4) and the diameter of the first type bristles may be varied such that a first type bristle packing density of from 50 per cm^2 to 1000 per cm^2 is obtained. Each first type bristle (3) is individually embedded in the head of the toothbrush (2). The first type bristles (3) as well as any other bristles utilized herein may be secured to the toothbrush head (2) by any process known in the art, including those mentioned hereinabove, or by a bonding method wherein an adhesive is utilized to attach the bristles to the toothbrush head.

A combination of first type bristle diameters ranging from about 0.25 mm to about 0.60 mm, and spacing between

immediately adjacent bristles ranging from about 0.5 times to about 10 times, preferably about 0.5 times to about 4 times, the diameter of the first type bristles (3) or any other bristles utilized in this invention may be utilized to provide different sensations for different parts of the mouth. For example, the first type bristles (3) may be arranged such that at least one section of the toothbrush head (2) contains first type bristles (3) having diameters ranging from about 0.35 mm to about 0.60 mm, while at least one other section of the toothbrush head (2) contains first type bristles (3) having diameters ranging from about 0.25 mm to about 0.35 mm.

The toothbrush may further include at least one dense tuft (8) of bristles. The skilled art worker will recognize that dense tuft (8) of bristles may be secured to the toothbrush head (2) by means known in the art, such as, but not limited to, fusion or stapling techniques. The bristles in this tuft may have diameters ranging from about 0.08 mm to about 0.40 mm and a free length ranging from about 7 mm to about 15 mm. The dense tuft (8) of bristles may be arranged anywhere on the toothbrush head (2). Preferably, the dense tuft (8) of bristles is distal to the toothbrush handle (1). Preferably, when the dense tuft (8) is distal to the toothbrush handle, the dense tuft has a

longer length than that of the bristles comprising the toothbrush.

In a second embodiment of the present invention, the toothbrush comprises: a handle; a toothbrush head distal to the handle; at least one second type bristle having a diameter of from about 0.08 mm to about 0.35 mm and a free length of from about 7 mm to about 16 mm; and at least one third type bristle having a diameter of from about 0.15 mm to about 0.40 mm and a free length of from about 5 mm to about 14 mm; wherein the trim difference between the second type bristle and the third type bristle ranges from about 0.5 mm to about 3 mm. This toothbrush is believed to provide enhanced cleaning performance.

The second type of bristle (5) must have a diameter which is sufficiently large to provide the bristle with enough inherent stiffness to be able to remove plaque, food debris, etc. from the teeth while remaining flexible enough to follow the contour of the oral surfaces during use. For this purpose, the second type of bristle (5) may have a diameter of from about 0.08 mm to about 0.35 mm, preferably from about 0.13 mm to about 0.35 mm, and a free length of from about 7 mm to about 16 mm, preferably from about 9 mm to about 14 mm. The second type bristles (5) may serve the purpose of interdental and subgingival cleaning.

The third type of bristle (6) may serve the purpose of cleaning the surfaces of the teeth. The third type of bristle (6) may have a diameter of from about 0.15 mm to about 0.40 mm, preferably from about 0.20 mm to about 0.40 mm and a free length of from about 5 mm to about 14 mm, preferably from about 7 mm to about 12 mm. A trim difference of from about 0.5 mm to about 3 mm is recommended between the free lengths of the second type (5) and third type (6) of bristles to ensure optimal cleaning interdentally and subgingivally. As used herein, the term "trim difference" means the difference in free lengths between different types of bristles.

The free lengths of the bristles within a given section of the toothbrush may be varied to also provide an improved perception of cleaning via visual and tactile stimuli. For example, a sawtooth cut or a zigzag cut reinforces the consumer's perception of interdental cleaning. Other patterns, such as but not limited to, waves, arcs, etc., can be used in place of the sawtooth cut or zigzag cut.

In one embodiment of the present invention, alternating sections of second type (5) and third type (6) bristles are contained in the toothbrush to enhance interproximal cleaning efficacy. In this embodiment, second type bristles (5), which may have a diameter of from about 0.08 mm to about 0.35 mm, preferably from

about 0.13 mm to about 0.35 mm, and a free length of from about 7 mm to about 16 mm, preferably from about 9 mm to about 14 mm, may be alternated with third type bristles (6), which may have a diameter of from about 0.15 mm to about 0.40 mm, preferably from about 0.20 mm to about 0.40 mm, and a free length of from about 5 mm to about 14 mm, preferably from about 7 mm to about 12 mm. The first sections contain second type bristles, and the second sections contain third type bristles. The sections may be from 1 to 7 rows deep. If each section is spaced at 2.15 times the diameter of each adjacent bristle and the transition is spaced at 2.15 times the average diameter of the adjoining bristles, the density of the third type bristle section may be 380-600 bristles per square centimeter while the density of the second type bristle section may be 100-350 bristles per square centimeter. The lower density of bristles is preferred since it allows for the use of thicker diameter bristles, which provide more cleaning sensation to the consumer.

Other patterns besides alternating rows may also be used for the varying length and diameter bristles and these include, but are not limited to alternating waves, a circle of longer bristles surrounding the shorter bristles along a row, a hexagon of longer bristles surrounding a shorter bristle, etc.

In another embodiment of the present invention, at least one of a fourth type of bristle (7) is contained in at least one section about the periphery of the toothbrush head (2). As used herein, by "periphery" is meant the outer edge of the upper surface of the toothbrush head. Elastomeric material such as, but not limited to rubber may be particularly suited as the material of construction for the fourth type of bristle. The fourth type bristles (7) may be of a diameter of from about 0.15 mm to about 1.0 mm, preferably about 0.30 mm to about 0.50 mm, and a free length of from about 9 mm to about 15 mm, preferably from about 10 mm to about 13 mm. In a preferred embodiment, a plurality of fourth type bristles (7) are arranged about the periphery of the toothbrush head. The free length of the fourth type bristles (7) may also alternate along the periphery of the toothbrush head, resulting in forms. Possible forms include, but are not limited to an arc shape, a sawtooth shape, or a wave shape. Combinations of these height patterns are possible as well, as are repeating patterns, such as a series of smaller arcs along the periphery or a sawtooth with an arcing midline.

The present invention may also provide a toothbrush having a multiplicity of bristle diameters and bristle spacing (4) within the toothbrush head (2) to provide different sensations for different parts of the mouth. Depending on the ratio of the different bristles used of

each diameter, and the spacing (4) used between bristles, the bristle density on the toothbrush head (2) can be varied from 50 to 1000 per square centimeter. The bristle density could also vary along various regions of the toothbrush head (2) such that one area may have a different bristle density than that of another area to provide the customer with desired tactile perception and visual cues.

The toothbrush may further include at least one dense tuft (8) of bristles. The bristles in the tuft may have diameters ranging from about 0.08 mm to about 0.40 mm and a free length ranging from about 7 mm to about 15 mm. The dense tuft (8) of bristles may be arranged anywhere on the toothbrush head (2). In one embodiment, the toothbrush includes at least one dense tuft with first type bristles; second type bristles; third type bristles; fourth type bristles; or combinations thereof. The dense tuft or tufts may be of any shape. In top plan, the dense tuft or tufts may be, for example, in the form of a circle, square, oval, triangle, elongated rectangle, polygonal, half-moon, horseshoe, bar, stars, arc and combinations thereof. Preferably, a dense tuft (8) of bristles is located at the tip of the free end of the brush head of the toothbrush to aid in cleaning the posterior teeth.

In a preferred embodiment, the present invention provides a toothbrush wherein the toothbrush head (2) contains second type bristles (5) which may have a diameter of from about 0.08 mm to about 0.35 mm, preferably from about 0.13 mm to about 0.35 mm, and a free length of from about 7 mm to about 16 mm, preferably from about 9 mm to about 14 mm throughout the toothbrush head (2; third type bristles (6) which may have a diameter of from about 0.15 mm to about 0.40 mm, preferably from about 0.20 mm to about 0.40 mm, and a free length of from about 5 mm to about 14 mm, preferably from about 7 mm to about 12 mm; and fourth type bristles (7) having a diameter of from about 0.15 mm to about 1.0 mm, preferably about 0.30 mm to about 0.50 mm, and a free length of from about 9 mm to about 15 mm, preferably about 10 mm to about 13 mm along the periphery of the toothbrush head (2). The toothbrush head contains a periphery and a distal end. At the distal end of the toothbrush head (2) is a dense tuft (8) of bristles for cleaning of the back teeth and gums. The bristles in the dense tuft (8) may have diameters ranging from about 0.08 mm to about 0.40 mm and a free length ranging from about 7 mm to about 15 mm. With the varying bristle patterns within this toothbrush, consumers receive not only a superior cleaning of their entire oral cavity (teeth surfaces, gums, interproximal regions, etc.) but also are able to perceive the better

clean through sensual cues (visual and tactile) delivered via the bristle configuration.

Brief Description of the Drawings

Descriptions of the Drawing Figures follow. The descriptions are intended to illustrate various aspects of the invention, but should not be construed as limiting the scope of the invention.

Figure 1 displays a toothbrush having a handle (1) and a toothbrush head (2) distal to the toothbrush handle. A multiplicity of first type bristles (3) of uniform length and diameter are embedded in the toothbrush head (2). The first type bristles (3) are mutually spaced apart from one another by a distance (4) from 0.5 times to 10 times the diameter of the bristles.

Figure 1A is a top plan view of the toothbrush shown in Figure 1.

Figure 2 displays a toothbrush having second type bristles (5) and third type bristles (6) embedded in the toothbrush head (2). The bristles are mutually spaced apart from one another by a distance (4) from 0.5 times to 10 times the diameter of the bristles. The second type bristles (5) are arranged in hexagonal shapes around the third type bristles (6).

Figure 3 displays a toothbrush having alternating rows of second type bristles (5) and third type bristles (6) embedded in the toothbrush head (2). The bristles are mutually spaced apart from one another by a distance (4) from 0.5 times to 10 times the diameter of the bristles.

Figure 3A is a top plan view of the toothbrush shown in Figure 3.

Figure 4 displays a toothbrush having alternating rows of second type bristles (5) and third type bristles (6) embedded in the toothbrush head (2). The bristles are mutually spaced (4) apart from one another by a distance from 0.5 times to 10 times the diameter of the bristles. Along the periphery of the toothbrush head (2) are fourth type bristles (7) embedded in the toothbrush head (2).

Figure 4A is a top plan view of the toothbrush shown in Figure 4.

Figure 5 displays a toothbrush having second type bristles (5) and third type bristles (6) embedded in the toothbrush head (2). The bristles are mutually spaced apart from one another by a distance (4) from 0.5 times to 10 times the diameter of the bristles. The second type bristles (5) are arranged in hexagonal shapes around the third type bristles (6). At the end of the

toothbrush head (2) distal to the handle (1), is a dense tuft of bristles (8).

Figure 5A is a top view of the toothbrush shown in Figure 5.

Figure 6 displays a toothbrush having second type bristles (5) and third type bristles (6) embedded in the toothbrush head (2). The bristles are mutually spaced apart from one another by a distance (4) from 0.5 times to 10 times the diameter of the bristles. The second type bristles (5) are arranged in hexagonal shapes around the third type bristles (6). At the end of the toothbrush head (2) distal to the handle (1), is a dense tuft of bristles (8). Along the periphery of the toothbrush head (2) are fourth type bristles (7) embedded in the toothbrush head (2).

Figure 6A is a top view of the toothbrush shown in Figure 6.

Figure 7 displays a toothbrush having alternating rows of second type bristles (5) and third type bristles (6) embedded in the toothbrush head (2). The bristles are mutually spaced apart from one another by a distance (4) from 0.5 times to 10 times the diameter of the bristles. At the end of the toothbrush head (2) distal to the handle (1), is a dense tuft of bristles (8). Along the

periphery of the toothbrush head (2) are fourth type bristles (7) embedded in the toothbrush head (2).
Figure 7A is a top view of the toothbrush shown in Figure 7.

Figure 8 displays a toothbrush having randomly distributed second type bristles (5) and third type bristles (6) embedded in the toothbrush head (2). The bristles are mutually spaced apart from one another by a distance (4) from 0.5 times to 10 times the diameter of the bristles. At the end of the toothbrush head (2) distal to the handle (1), is a dense tuft of bristles (8). Along the periphery of the toothbrush head (2) are fourth type bristles (7) embedded in the toothbrush head (2).

Figure 8A is a top view of the toothbrush shown in Figure 8.

Figure 9 displays a perspective view of a toothbrush having a multiplicity of individually embedded first type bristles (3) and a multiplicity of dense tufts (8) of bristles embedded in the toothbrush head (2).

Figure 9A is a top plan view of the toothbrush shown in Figure 9.

Figures 10 and 11 are perspective views of different embodiments of a toothbrush having a multiplicity of individually embedded first type bristles (3) and a multiplicity of dense tufts (8) of bristles embedded in the toothbrush head (2).

Figures 10A and 11A are top plan views of the toothbrushes shown in Figures 10 and 11, respectively.

Several examples of the invention are set forth below to further illustrate the nature of the invention and the manner of carrying it out. However, the invention should not be considered as being limited to the details thereof.

Example 1

A toothbrush was made according to the design shown in Figure 8. The bristles of the toothbrush according to Figure 8 had the following diameters: second type bristles (5): 0.18 mm; third type bristles (6): 0.23 mm; fourth type bristles (7): 0.2 mm; and dense tuft of bristles (8): 0.25 mm. The heights of the bristles were as follows: second type bristles: 9-10 mm; third type bristles: 10.5 mm; fourth type bristles: 10-11.25 mm; and dense tuft of bristles: 12.5 mm. The space between the exterior adjacent surfaces of the second type bristles (5) was about 0.021 mm; the corresponding

space between the exterior surfaces of the third type bristles (6) was about 0.0197 mm; the space between the exterior adjacent surfaces of the fourth type bristles (7) was about 0.018 mm; and the space between the exterior surfaces of the individual bristles comprising the dense tuft (8) of bristles was about 0.020 mm.

Two toothbrushes were made according to the design shown in Figure 11. First toothbrush (Sample 11A) had bristles of the following diameters: first type bristles (3): 0.20 mm; dense tufts (8) of bristles throughout the toothbrush head: 0.20 mm; and distal dense tuft (8): of bristles 0.20 mm. The heights of the bristles were as follows: first type bristles (3): 11 mm; dense tufts of bristles throughout the toothbrush head: 9 mm; and distal dense tuft (8) of bristles 12.5 mm. Second toothbrush (Sample 11B) had the following bristle diameters: first type bristles (3): 0.20 mm; dense tufts (8) of bristles throughout the toothbrush head: 0.18 mm; and distal dense tuft (8): of bristles 0.20 mm. The heights of the bristles were as follows: first type bristles (3): 11 mm; dense tufts (8) of bristles throughout the toothbrush head: 9 mm; and distal dense tuft (8) of bristles: 12.5 mm. In each sample 11A, 11B, the first type bristles (3) were individually embedded in toothbrush head 2.

The above-described three toothbrushes were tested for efficacy at cleaning between the teeth according to the procedure described in "Access to interproximal tooth surfaces by different bristle designs and stiffnesses of toothbrushes", Nygaard-Ostby et al., Scand. J. Dent Res. 1979, 87, 424-430, the disclosure of which is incorporated herein by reference. The results of the tests are reported in Table 1.

Table 1

Sample	Between Teeth Access (mm)
Figure 8	12
11A	11.8
11B	12.6
Oral B Cross Action	10.8
Oral B Indicator	7.7

The data above demonstrates that the toothbrushes according to the present invention clean between the teeth better than commercially available toothbrushes.

Example 2

The efficacy of the toothbrush of Figure 8 and the Oral B* Indicator toothbrush was tested by a clinical trial. An examiner-blind, randomized, crossover clinical study was conducted with seventy healthy adults. Plaque was evaluated before and after brushing for one minute using

the Rustogi Modification of the Navy Plaque Index ("RMNPI"). Subjects were randomly assigned to use one of the two test toothbrushes, namely the Oral B* Indicator toothbrush or the toothbrush made according to the design shown in Figure 8. After brushing at the initial visit, the subjects returned two weeks later to repeat the procedure with the other of the two test toothbrushes. Evaluation of plaque using RMNPI was done at both visits. RMNPI scores were given for the whole mouth, interproximal sites, marginal sites, behind the last molar, anterior sites, and posterior sites. The change in plaque from pre-brushing to post brushing was compared for both toothbrushes. The results are shown in Table 2.

Table 2

	Plaque Scores					
	Invention*			Oral B Indicator		
Tooth Site	Pre	Post	delta	Pre	Post	delta
Whole Mouth	0.64	0.30	52.8	0.64	0.36	44.1
Marginal	1	0.63	37.1	1	0.71	28.9
Interproximal	1	0.38	61.9	1	0.47	52.9
Last Molar	0.58	0.23	60	0.57	0.31	45.8
Anterior	0.65	0.30	54	0.65	0.34	48
Posterior	0.64	0.31	51.8	0.64	0.38	40.7

*Toothbrush of Figure 8.

The scores reported are the mean scores for the groups of participants. The term "delta" is the percent reduction in plaque for each group from before brushing to after brushing. Using statistical techniques, it was concluded that the toothbrush of the invention removed significantly more plaque than a commercially available toothbrush from the whole mouth, gingival margin, interproximal surface, and behind the last molar, respectively 20%, 28%, 17%, and 31% more.

Toothbrushes in accordance with the present invention provide efficient tooth cleaning, are easily cleaned, and dry in a relatively short period of time.